



PATENT  
Serial No. 09/777,471 (89190.157900/DP-303637)  
Response to Office Action dated February 24, 2005

### Amendment to the Claims

This listing of claims will replace all prior versions and listings of claims in the application:

#### Listing of Claims:

1. (Cancelled).
2. (Cancelled).
3. (Currently amended) A solenoid for providing linear actuation, comprising:
  - a) first and second polepieces having axial bores coaxially disposed along a common axis;
  - b) an electrical conductor wound about said polepieces in a plurality of turns;
  - c) an armature movably disposed in said axial bores, wherein said armature includes an outer surface, wherein at least a portion of said outer surface is frusto-conical, said frusto-conical section portion of said outer surface being adjacent to a substantial portion of said first and second polepieces;
  - d) a bearing axially retained in one of said first and second polepieces, said axial bore of said polepiece not retaining said bearing being non-frusto-conical; and

e) a shaft attached coaxially to said armature and extending through a supportive bore in said bearing wherein said bearing radially supports said shaft, said shaft being axially displaceable by electromagnetic displacement of said armature to provide said actuation, wherein said armature is entirely separated from said axial bores of said polepieces by a generally cylindrical an air gap, and wherein the armature is prevented from contacting the polepieces.

4. (Previously presented) A solenoid in accordance with Claim 3 wherein said solenoid is included in an actuator attachable to a device for providing linear actuation to said device.

5. (Cancelled).

6. (Currently amended) A valve assembly for exhaust gas recirculation between the exhaust manifold and the intake manifold of an internal combustion engine, said assembly including an exhaust gas recirculation valve and further including a solenoid actuator attached to said valve, said solenoid actuator having first and second polepieces having axial bores coaxially disposed along a common axis, an electrical conductor wound about said polepieces in a plurality of turns, a frusto-conical an armature movably disposed in said axial bores, said armature including an outer surface, wherein at least a portion of said outer surface is frusto-conical, said frusto-conical section portion of said outer surface being adjacent to a substantial portion of said first and second

polepieces, a bearing axially retained in one of said first and second polepieces, said axial bore of said polepiece not retaining said bearing being non-frusto-conical, and a shaft attached coaxially to said armature and extending through a supportive bore in said bearing wherein said bearing radially supports said shaft, said shaft being axially displaceable by electromagnetic displacement of said armature to provide actuation of said valve, wherein said armature is entirely separated from said axial bores of said polepieces by a generally cylindrical an air gap, and wherein the armature is prevented from contacting the polepieces.

7. (Currently amended) An internal combustion engine, comprising:

- a) an intake manifold;
- b) an exhaust manifold; and
- c) a valve assembly for exhaust gas recirculation between said

exhaust manifold and said intake manifold, said assembly including an exhaust gas recirculation valve and further including a solenoid actuator attached to said valve and having first and second polepieces having axial bores coaxially disposed along a common axis, an electrical conductor wound about said polepieces in a plurality of turns, a frusto-conical an armature movably disposed in said axial bores, said armature including an outer surface, wherein at least a portion of said outer surface is frusto-conical, said frusto-conical section portion of said outer surface being adjacent to a substantial portion of said first and second polepieces, a bearing axially retained in one of said first and second polepieces, said axial bore of said polepiece not retaining said bearing being

non-frusto-conical, and a shaft attached coaxially to said armature and extending through a supportive bore in said bearing wherein said bearing radially supports said shaft, said shaft being axially displaceable by electromagnetic displacement of said armature to provide actuation of said valve to admit exhaust gas from said exhaust manifold into said intake manifold, wherein said armature is entirely separated from said axial bore of said polepieces by ~~a generally cylindrical~~ an air gap, and wherein the armature is prevented from contacting the polepieces.

8. (Cancelled).

9. (Cancelled).

10. (Currently amended) A solenoid for providing linear actuation, comprising:

- a) a housing;
- b) first and second polepieces, within said housing, having axial bores coaxially disposed along a common axis;
- c) an electrical conductor wound about said polepieces in a plurality of turns;
- d) an armature movably disposed in said axial bores, wherein said armature includes an outer surface, wherein at least a portion of said outer surface is frusto-conical, said frusto-conical section portion of said outer surface being adjacent to a substantial portion of said first and second polepieces;

- e) a bearing axially retained in one of said first and second polepieces, said axial bore of said polepiece not retaining said bearing being non-frusto-conical; and
- f) a shaft attached coaxially to said armature and extending through a supportive bore in said bearing wherein said bearing radially supports said shaft, said shaft being axially displaceable by electromagnetic displacement of said armature to provide said actuation, wherein said armature is entirely separated from said axial bore of said polepieces by ~~a generally cylindrical~~ an air gap, and wherein the armature is prevented from contacting the polepieces.

11. (Previously presented) A solenoid in accordance with Claim 10 wherein said solenoid is included in an actuator attachable to a device for providing linear actuation to said device.

12. (Cancelled).

13. (Previously presented) A solenoid for providing linear actuation, comprising:

- a) first and second polepieces having axial bores coaxially disposed along a common axis;
- b) an electrical conductor wound about said polepieces in a plurality of turns;
- c) an armature movably disposed in said axial bores;

d) a bearing axially retained in one of said first and second polepieces; and

e) a shaft attached coaxially to said armature and extending through a supportive bore in said bearing wherein said bearing radially supports said shaft, said shaft being axially displaceable by electromagnetic displacement of said armature to provide said actuation, wherein said armature is entirely separated from said axial bores of said polepieces by a generally cylindrical air gap, and wherein said bearing has an axial length that is at least 1.5 times larger than the diameter of said shaft.

14. (Previously presented) A solenoid in accordance with Claim 6 wherein said bearing has an axial length that is at least 1.5 times larger than the diameter of said shaft.

15. (Previously presented) A solenoid in accordance with Claim 7 wherein said bearing has an axial length that is at least 1.5 times larger than the diameter of said shaft.

16. (Previously presented) A solenoid in accordance with Claim 10 wherein said bearing has an axial length that is at least 1.5 times larger than the diameter of said shaft.